Department of Computer Science & Engineering

CourseNo : **CSE2106**
Course Title : **Digital Logic Design Sessional**

Experiment No : **05**
Experiment Name : a)Design a switch(s) controlled Even/Odd parity checker circuit for 4 bit data
if S=0 then Even parity
if S=1 then Odd parity
b)Design a Excess-4 to BCD Converter Circuit
c)Design a switch(s) controlled 4 bit Binary to Gray & Gray to Binary code conversion circuit
if S=0 then Gray to Binary Code
if S=1 then Binary to Gray Code

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Experiment Name: Design a switch(s) controlled even/odd Parity checker circuit for 4-bit Data. If s=0, then Even parity. If s=1 then odd parity.

Objective: To make a number of 1's either odd or even, a extra bit is included with a binary message which is called parity bit. The receiver checks even/odd parity as a result of the calculation of the number of 1's in the message bit. If the number is even, F gets the value 1 & if the number is odd, the F gets 0. At odd parity, F gets 1 when the number of 1's is odd and 0 when the number of 1's is even. Our objective is to check a switch controlled even/odd parity circuit for 4 bit.

Truth Table:

Input					Output
S	A	B	C	D	F
0	0	0	0	0	1
0	0	0	0	1	0
0	0	0	1	0	0
0	0	0	1	1	1
0	0	1	0	0	0
0	0	1	0	1	1
0	0	1	1	0	1
0	0	1	1	1	0
0	1	0	0	0	0
0	1	0	0	1	1
0	1	0	1	0	1
0	1	0	1	1	0
0	1	1	0	0	1
0	1	1	0	1	0
0	1	1	1	0	0
0	1	1	1	1	1
1	0	0	0	0	0
1	0	0	0	1	1
1	0	0	1	0	1
1	0	0	1	1	0
1	0	1	0	0	1
1	0	1	0	1	0
1	0	1	1	0	0
1	0	1	1	1	1
1	1	0	0	0	1
1	1	0	0	1	0
1	1	0	1	0	0
1	1	0	1	1	1
1	1	1	0	0	0
1	1	1	0	1	1
1	1	1	1	0	1
1	1	1	1	1	0

Here $F_0 = \Sigma(0,3,5,6,9,10,12,15,17,18,20,23,24,27,29,30)$

k-map:

$SA \backslash BCD$	$\bar{B}\bar{C}\bar{D}$	$\bar{B}\bar{C}D$	$\bar{B}CD$	$\bar{B}C\bar{D}$	$BC\bar{D}$	BCD	$B\bar{C}D$	$B\bar{C}\bar{D}$
$\bar{S}\bar{A}$	1		1		1		1	
$\bar{S}A$		1		1		1		1
SA	1		1		1		1	
$S\bar{A}$		1		1		1		1

$$F = \bar{S}\bar{A}\bar{B}\bar{C}\bar{D} + \bar{S}\bar{A}\bar{B}CD + \bar{S}\bar{A}BC\bar{D} + \bar{S}\bar{A}B\bar{C}D + \bar{S}A\bar{B}\bar{C}D + \bar{S}A\bar{B}C\bar{D} + \bar{S}ABCD + \bar{S}AB\bar{C}\bar{D} + SA\bar{B}\bar{C}\bar{D} + SA\bar{B}CD + SABC\bar{D} + SAB\bar{C}D + S\bar{A}\bar{B}\bar{C}D + S\bar{A}\bar{B}C\bar{D} + S\bar{A}BCD + S\bar{A}B\bar{C}\bar{D}$$

$$= S\bar{A}\bar{B}(\bar{C}\bar{D}+CD) + \bar{S}\bar{A}B(\bar{C}D+C\bar{D}) + \bar{S}A\bar{B}(\bar{C}D+C\bar{D}) + \bar{S}AB(CD+\bar{C}\bar{D}) + SA\bar{B}(\bar{C}\bar{D}+CD) + SAB(C\bar{D}+\bar{C}D) + S\bar{A}\bar{B}(\bar{C}D+C\bar{D}) + S\bar{A}B(CD+\bar{C}\bar{D})$$

[Distributive Law]

$$= S\bar{A}\bar{B}(\overline{C\oplus D}) + \bar{S}\bar{A}B(C\oplus D) + \bar{S}A\bar{B}(C\oplus D) + \bar{S}AB(\overline{C\oplus D}) + SA\bar{B}(\overline{C\oplus D}) + SAB(C\oplus D) + S\bar{A}\bar{B}(\bar{C}D+C\bar{D}) + S\bar{A}B(\overline{C\oplus D})$$ [Definition of X-OR, X-NOR]

$$= \bar{S}\bar{A}\bar{B}(\overline{C\oplus D}) + \bar{S}AB(\overline{C\oplus D}) + \bar{S}\bar{A}B(C\oplus D) + \bar{S}A\bar{B}(C\oplus D) + SA\bar{B}(\overline{C\oplus D}) + S\bar{A}B(\overline{C\oplus D}) + SAB(C\oplus D) + S\bar{A}\bar{B}(C\oplus D)$$ [Commutative Law]

$$= \bar{S}(\bar{A}\bar{B}+AB)(\overline{C\oplus D}) + \bar{S}(\bar{A}B+A\bar{B})(C\oplus D) + S(A\bar{B}+\bar{A}B)(\overline{C\oplus D}) + S(AB+\bar{A}\bar{B})(C\oplus D)$$ [Distributive Law]

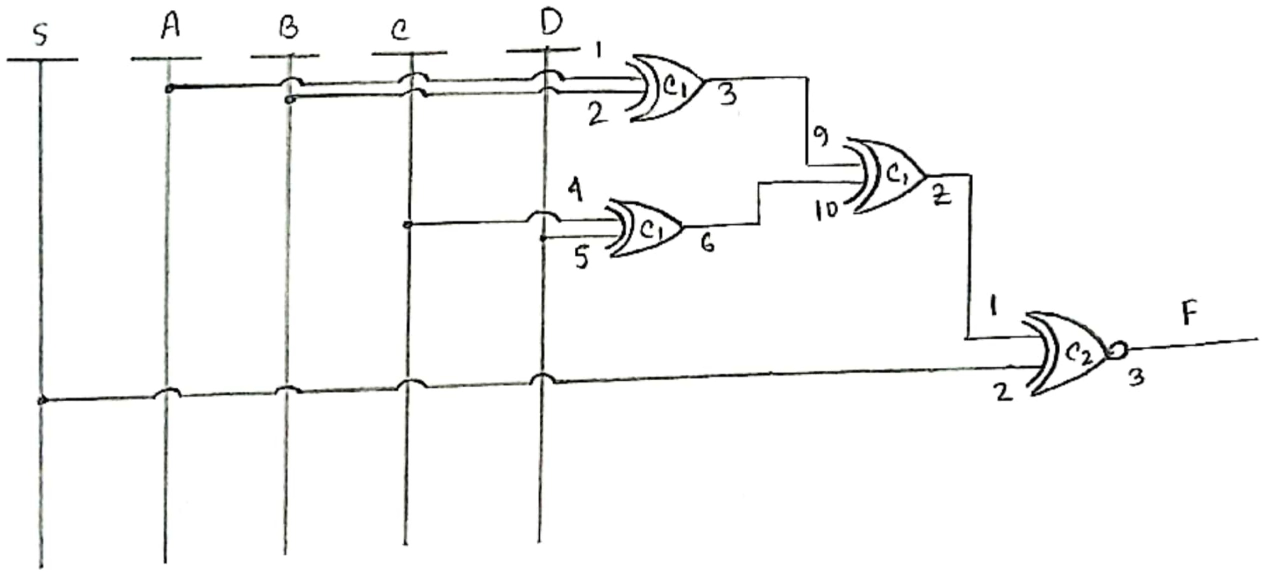
$$= \bar{S}(\overline{A\oplus B})(\overline{C\oplus D}) + \bar{S}(A\oplus B)(C\oplus D) + S(A\oplus B)(\overline{C\oplus D}) + S(\overline{A\oplus B})(C\oplus D)$$ [Distributive Law]

$$= \bar{S}\left(\overline{(A\oplus B)\oplus(C\oplus D)}\right) + S\left((A\oplus B)\oplus(C\oplus D)\right)$$ [Definition of X-OR, X-NOR]

$$= \overline{S\oplus((A\oplus B)\oplus(C\oplus D))}$$ [Definition of X-NOR]

Using k-map the simplified expression is, $F = \overline{S \oplus ((A \oplus B) \oplus (C \oplus D))}$

Circuit Diagram:



IC Requirements:

1. C_1 – 74LS86 (X-OR Gate) – 1 piece
2. C_2 – 74LS266 (X-NOR Gate) – 1 piece

Conclusion: In this experiment, we have learnt that it is a 4-bit switch controlled odd and even parity and we can check for both odd and even parity. From the truth table and the k-map we have obtained the simplified expression which we implemented in the circuit with proper IC requirements.

Experiment Name: Design a excess-4 to BCD converter circuit

Objective: BCD is the abbribiation of Binary Coded Decimal and Excess-4 codes are unweighted codes which are obtained by adding 4 to each decimal digit and can be represented by binary representation. In this experiment, we are going to design a circuit of Excess-4 to BCD and using k-map to obtain simplified expression.

Truth Table:

Decimal	Excess-4				BCD			
Value	A	B	C	D	w	x	y	z
0	0	0	0	0	X	X	X	X
1	0	0	0	1	X	X	X	X
2	0	0	1	0	X	X	X	X
3	0	0	1	1	X	X	X	X
4	0	1	0	0	0	0	0	0
5	0	1	0	1	0	0	0	1
6	0	1	1	0	0	0	1	0
7	0	1	1	1	0	0	1	1
8	1	0	0	0	0	1	0	0
9	1	0	0	1	0	1	0	1
10	1	0	1	0	0	1	1	0
11	1	0	1	1	0	1	1	1
12	1	1	0	0	1	0	0	0
13	1	1	0	1	1	0	0	1
14	1	1	1	0	X	X	X	X
15	1	1	1	1	X	X	X	X

Function Evaluation:

For $\omega = \Sigma(12,13)$ $d = \Sigma(0,1,2,3,14,15)$

k-map:

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	X	X	X	X
$\bar{A}B$				
AB	1	1	X	X
$A\bar{B}$				

Using k-map, the simplified function is $w = AB$

For x, $x = \Sigma(8,9,10,11)$ $d = \Sigma(0,1,2,3,14,15)$

k-map:

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	X	X	X	X
$\bar{A}B$				
AB			X	X
$A\bar{B}$	1	1	1	1

Using k-map, the simplified function is $x = \bar{B}$

For y, $y = \Sigma(6,7,10,11)$ $d = \Sigma(0,1,2,3,14,15)$

k-map:

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	X	X	X	X
$\bar{A}B$			1	1
AB			X	X
$A\bar{B}$			1	1

Using k-map, the simplified function is $y = C$

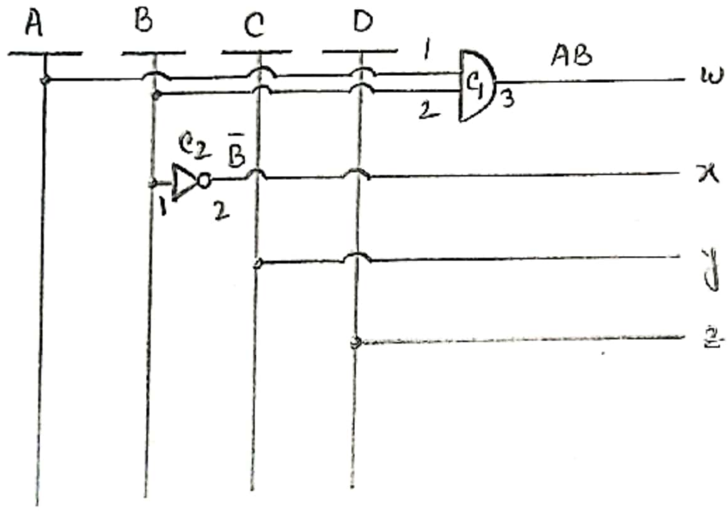
For z, $z = \Sigma(5,7,9,11,13)$ $d = \Sigma(0,1,2,3,14,15)$

k-map:

AB \ CD	$\bar{C}\bar{D}$	$\bar{C}D$	CD	$C\bar{D}$
$\bar{A}\bar{B}$	x	x	x	x
$\bar{A}B$		1	1	
AB		1	x	x
$A\bar{B}$		1	1	

Using k-map the simplified function is, $z = D$

Circuit Diagram:



IC Requirements:

i) $C_1 \rightarrow$ 74LS08 (AND Gate) - 1 piece
ii) $C_2 \rightarrow$ 74LS04 (NOT Gate) - 1 piece

Conclusion: In this experiment, we have learned the convertion of Excess-4 to BCD where (0-3) and (14-15) were don't cares. From the truth table and k-map we have got the minimized expression and implemented it on the circuit with proper IC requirements.

Experiment Name: Design a switch controlled 4-bit binary to Gray and Gray to binary code conversion circuit.

If s=0 then Gray to Binary Code

If s=1 then Binary to Gray Code

Objective: Binary code is a group of binary bits which are used to store, represent and transmit data is called binary code. On the other hand, Gray code is a non-weighted code. The successive gray code differ in one bit positions. The objective is to design a switch controlled binary to Gray and Gray to binary converter.

Truth Table:

Input					Output			
S	A	B	C	D	w	x	y	z
0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	1
0	0	0	1	0	0	0	1	0
0	0	0	1	1	0	0	1	1
0	0	1	0	0	0	1	0	0
0	0	1	0	1	0	1	0	1
0	0	1	1	0	0	1	1	0
0	0	1	1	1	0	1	1	1
0	1	0	0	0	1	0	0	0
0	1	0	0	1	1	0	0	1
0	1	0	1	0	1	0	1	0
0	1	0	1	1	1	0	1	1
0	1	1	0	0	1	1	0	0
0	1	1	0	1	1	1	0	1
0	1	1	1	0	1	1	1	0
0	1	1	1	1	1	1	1	1
1	0	0	0	0	0	0	0	0
1	0	0	0	1	0	0	0	1
1	0	0	1	0	0	0	1	1
1	0	0	1	1	0	0	1	0
1	0	1	0	0	0	1	1	0
1	0	1	0	1	0	1	1	1
1	0	1	1	0	0	1	0	1
1	0	1	1	1	0	1	0	0
1	1	0	0	0	1	1	0	0
1	1	0	0	1	1	1	0	1
1	1	0	1	0	1	1	1	1
1	1	0	1	1	1	1	1	0
1	1	1	0	0	1	0	1	0
1	1	1	0	1	1	0	1	1
1	1	1	1	0	1	0	0	1
1	1	1	1	1	1	0	0	0

Here, $w = \Sigma(8,9,10,11,12,13,14,15,24,25,26,27,28,29,30,31)$

<u>k-map:</u>

$SA \backslash BCD$	$\bar{B}\bar{C}\bar{D}$	$\bar{B}\bar{C}D$	$\bar{B}CD$	$\bar{B}C\bar{D}$	$BC\bar{D}$	BCD	$B\bar{C}D$	$B\bar{C}\bar{D}$
$\bar{S}\bar{A}$	0	0	0	0	0	0	0	0
$\bar{S}A$	1	1	1	1	1	1	1	1
SA	1	1	1	1	1	1	1	1
$S\bar{A}$	0	0	0	0	0	0	0	0

Using k-map, simplified expression is, $w = A$

Here, $x = \Sigma(4,5,6,7,8,9,10,11,20,21,22,23,24,25,26,27)$

$SA \backslash BCD$	$\bar{B}\bar{C}\bar{D}$	$\bar{B}\bar{C}D$	$\bar{B}CD$	$\bar{B}C\bar{D}$	$BC\bar{D}$	BCD	$B\bar{C}D$	$B\bar{C}\bar{D}$
$\bar{S}\bar{A}$	0	0	0	0	1	1	1	1
$\bar{S}A$	1	1	1	1	0	0	0	0
SA	1	1	1	1	0	0	0	0
$S\bar{A}$	0	0	0	0	1	1	1	1

Using k-map, the simplified expression is, $x = A\bar{B} + \bar{A}B = A \oplus B$

Here, $y = \Sigma(2,3,4,5,8,9,14,15,18,19,20,21,26,27,28,29)$

$SA \backslash BCD$	$\bar{B}\bar{C}\bar{D}$	$\bar{B}\bar{C}D$	$\bar{B}CD$	$\bar{B}C\bar{D}$	$BC\bar{D}$	BCD	$B\bar{C}D$	$B\bar{C}\bar{D}$
$\bar{S}\bar{A}$	0	0	1	1	0	0	1	1
$\bar{S}A$	1	1	0	0	1	1	0	0
SA	0	0	1	1	0	0	1	1
$S\bar{A}$	0	0	1	1	0	0	1	1

$y = \bar{A}\bar{B}C + S\bar{B}C + \bar{S}ABC + \bar{A}B\bar{C} + SB\bar{C} + \bar{S}A\bar{B}\bar{C}$

$= \bar{S}ABC + \bar{S}A\bar{B}\bar{C} + S\bar{B}C + SB\bar{C} + \bar{A}\bar{B}C + \bar{A}B\bar{C}$ [Commutative Law]

$= \bar{S}A(BC+\bar{B}\bar{C}) + S(\bar{B}C+B\bar{C}) + \bar{A}(B\bar{C}+\bar{B}C)$ [Distributive Law]

$= \bar{S}A(\overline{B \oplus C}) + S(B \oplus C) + \bar{A}(B \oplus C)$ [Definition of X-OR and X-NOR]

$= \bar{S}A(\overline{B \oplus C}) + (S+\bar{A})(B \oplus C)$ [Distributive Law]

$= \bar{S}A(\overline{B \oplus C}) + (\overline{\overline{S+\bar{A}}})(B \oplus C)$ [Double Negation]

$= \bar{S}A(\overline{B \oplus C}) + \overline{\bar{S}.\bar{\bar{A}}}\,(B \oplus C)$ [De Morgan's Law]

$= \bar{S}A(\overline{B \oplus C}) + \overline{\bar{S}.A}\,(B \oplus C)$ [Double Negation]

$= \bar{S}A \oplus B \oplus C$ [Definition of X-OR]

$\therefore y = \bar{S}A \oplus B \oplus C$ [using k-map]

Now, $z = \Sigma(1,2,4,7,8,11,13,14,17,18,21,22,25,26,29,30)$

SA \ BCD	$\bar{B}\bar{C}\bar{D}$	$\bar{B}\bar{C}D$	$\bar{B}CD$	$\bar{B}C\bar{D}$	$BC\bar{D}$	BCD	$B\bar{C}D$	$B\bar{C}\bar{D}$
$\bar{S}\bar{A}$	0	1	0	1	0	1	0	1
$\bar{S}A$	1	0	1	0	1	0	1	0
SA	0	1	0	1	1	0	1	0
$S\bar{A}$	0	1	0	1	1	0	1	0

$z = S\bar{C}D + SC\bar{D} + \bar{A}\bar{B}\bar{C}D + \bar{A}\bar{B}C\bar{D} + AB\bar{C}D + ABC\bar{D} + \bar{S}\bar{A}BCD + \bar{S}\bar{A}B\bar{C}\bar{D} +$
$\bar{S}A\bar{B}\bar{C}\bar{D} + \bar{S}A\bar{B}CD$

$= S(\bar{C}D+C\bar{D}) + \bar{A}\bar{B}(\bar{C}D+C\bar{D}) + AB(\bar{C}D+C\bar{D}) + \bar{S}\bar{A}B(CD+\bar{C}\bar{D}) +$
$\bar{S}A\bar{B}(\bar{C}\bar{D}+CD)$ [Distributive Law]

$= S(C \oplus D) + \bar{A}\bar{B}(C \oplus D) + AB(C \oplus D) + \bar{S}\bar{A}B(\overline{C \oplus D}) + \bar{S}A\bar{B}(\overline{C \oplus D})$

[Definition of X-OR and X-NOR]

$= (S + \bar{A}\bar{B} + AB)(C \oplus D) + \bar{S}(\bar{A}B + A\bar{B})(\overline{C \oplus D})$ [Distributive Law]

$= (S + \overline{A \oplus B})(C \oplus D) + \bar{S}(A \oplus B)(\overline{C \oplus D})$ [Definition of X-OR and X-NOR]

$= (\overline{\overline{S + \overline{A \oplus B}}})(C \oplus D) + \bar{S}(A \oplus B)(\overline{C \oplus D})$ [Complement Law]

$= \overline{\bar{S} \cdot (\overline{\overline{A \oplus B}})}\,(C \oplus D) + \bar{S}(A \oplus B)(\overline{C \oplus D})$ [De-Morgan's Law]

$= \overline{\bar{S} \cdot (A \oplus B)}\,(C \oplus D) + \bar{S}(A \oplus B)(\overline{C \oplus D})$ [Double Negation]

$= \bar{S}(A \oplus B) \oplus (C \oplus D)$ [Definition of X-OR]

$Z = \bar{S}(A \oplus B) \oplus (C \oplus D)$

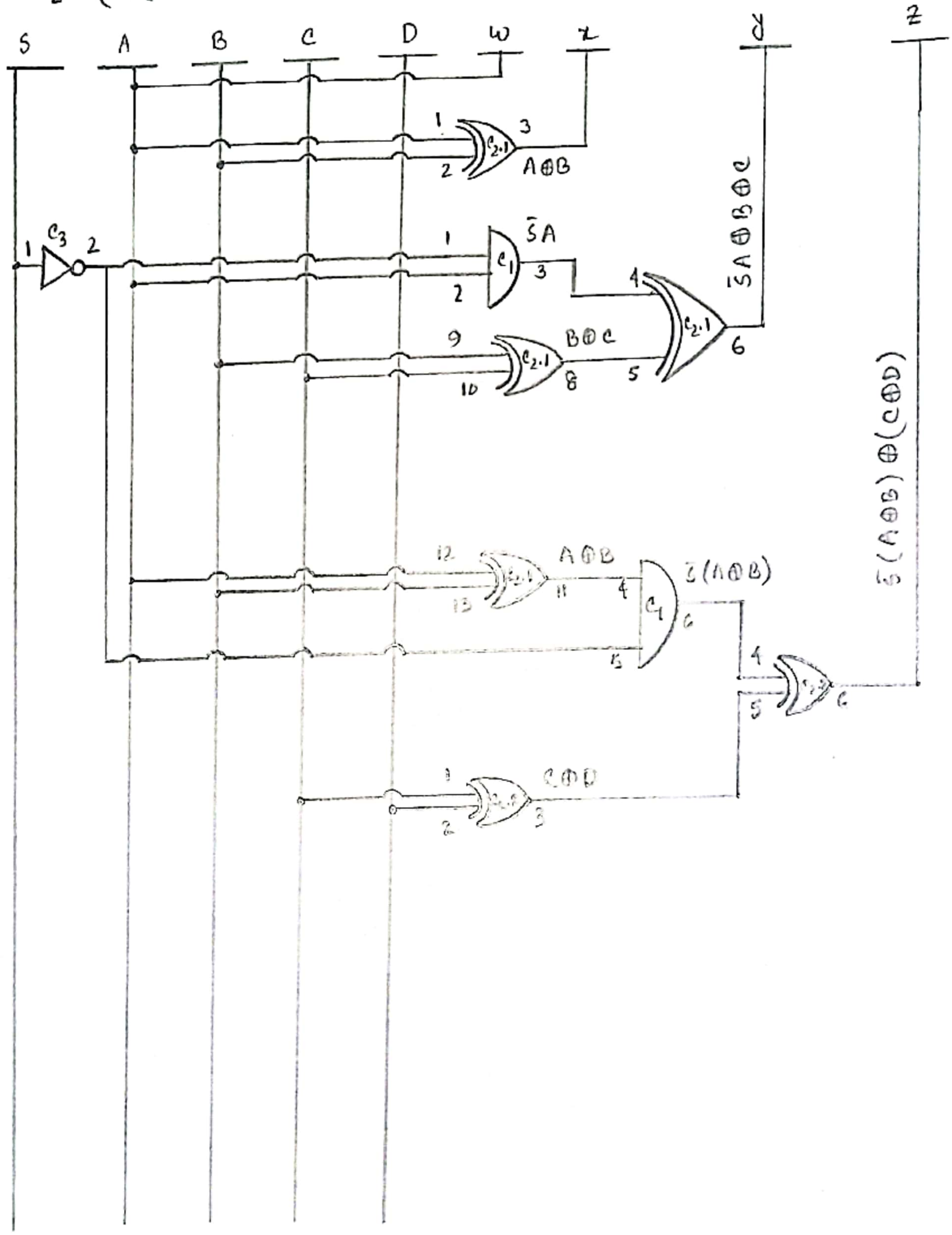
Circuit Diagram:

$w = A$

$x = A \oplus B$

$y = (\bar{S}A) \oplus B \oplus C$

$z = (\bar{S}(A \oplus B)) \oplus (C \oplus D)$



IC Requirements:

1. $C_1 \rightarrow$ 74LS08 (AND Gate) - 1 piece
2. $C_2 \rightarrow$ 74LS86 (XOR Gate) - 2 pieces
3. $C_3 \rightarrow$ 74LS04 (NOT Gate) - 1 piece

Conclusion: From the experiment, we have learnt that it is a 4-bit switch controlled Binary to Gray and Gray to Binary code converter. if s = 0, then (0-15) will be converted into gray to binary, when s = 1 then (16-31) will be converted into binary to gray. And implemented the minimized expressions in the circuit.